**Lifting the Cover of Those Ubiquitous Touch Screens**

By MATT LAKE

SOMETIMES a computer mouse just isn’t easy enough to use. When bank customers are taking money from automated teller machines or restaurant workers are tallying bills, grabbing an electronic device ensnared in a handful of plastic doesn’t come naturally at all.

That’s when people find the original pointing device — the index finger or its surrogate, the stylus — much more efficient and easier to use. That is why touch-screen technology was developed and why it is now used for everything from palm-size computers to controllers in airplane cockpits.

Touch screens combine two separate technologies, one to display items on a screen and the other to controllers in airplane cockpits.

Touch screens use one of four different technologies to detect touch, and electronic controllers and software drivers to communicate that information to a computer. The touch sensor system must be calibrated so a touch can be correlated exactly to the right spot. Two of the technologies, called resistive overlay and capacitive overlay, can drift out of synchronization and need to be recalibrated periodically.

The other two use ultrasound or infrared signals and tend to stay aligned.

The earliest touch-screen technology, which is also the most widespread and least expensive, is the resistive overlay. Resistive overlays were first developed by Elographics, a company in Oak Ridge, Tenn. Elographics (which has since changed its name to Elo TouchSystems) came up with the idea of overlaying two conductive sheets separated by a mesh of tiny raised dots, then passing electricity through one layer. When the screen was touched, it would make contact between the two layers, letting the electricity take a shortcut. That interruption of the flow of electricity is at a measurable point — one that can be determined precisely enough to register the touch of a stylus tip.

The resistive overlay system has a few drawbacks, but it is the system used in Palm and Pocket PC devices. The overlay is susceptible to abrasion, which rules out its use in public kiosks. And the thin conductive layers do block some light from the display screen. At first, up to 35 percent of the light was blocked; that’s now down to about 18 percent.

More light makes its way through capacitive overlay touch screens, which has helped that technology catch on, especially for gambling machines, where graphics are important. When the screen is touched, the user draws a small amount of electricity to the point of contact, so that touch can be detected. The capacitive coating is thinner and harder than the glass it is applied to, which makes it more durable for public uses. But the user cannot wear gloves or point at the screen with a stylus or pen.

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That gave rise to another type of touch sensor system, called surface acoustic wave technology, that combines durability with sensitivity. Surface wave touch screens do not require any opaque overlay so their displays are bright — and they do not require periodic recalibration. These screens detect the absorption of ultrasonic waves at the point of touch.

Like capacitive screens, acoustic wave screens are robust. That’s why they are used in machines dispensing Metrocards for riding the subways and buses in New York City. Many banks use the technology in automated teller machines. The screen can become quite dirty and dusty without giving false readings.

A recent addition to the touch-screen pantheon, infrared screens, use a “Mission Impossible-style” grid of infrared light and sensors to detect the point of touch. Infrared screens tolerate a range of temperatures and do not require frequent recalibration, which makes them suitable for use in airplane cockpits and A.T.M.’s alike.

**A Sandwich of Layers Gives a Screen Just the Right Touch**

**Resistive overlay screens**

Used for point-of-sale terminals in stores, hotels and restaurants, and, as shown here, in hand-held computers like the Visor.

A resistive screen is a sandwich with two conductive layers that are kept apart, usually by a grid of tiny insulating dots. Pressure from a finger or stylus pushes the two layers together, creating an electrical contact.
A Sandwich of Layers Gives a Screen Just the Right Touch

A screen has to perform two separate tasks: it must display a screen full of items to point at, and it must detect which ones you’re pointing at. The display screens are like television sets or computer monitors, but there are four different technologies for detecting the touch of a finger.

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**Other types**

- **Capacitive overlay**, kiosks, gambling machines.
  - Glass overlay is coated on both sides with a transparent layer of metal, with a protective glass layer on top. Current is passed through the metal coating. When finger touches the screen, minute electrical charges on the finger attract current from the screen. Electrical flow is measured from each corner to determine finger position.

- **Scanning infrared**, automatic tellers, medical instruments, kiosks, vehicles.
  - The screen is surrounded by rows of light-emitting diodes and detectors. The L.E.D.'s send infrared beams across the screen. A finger blocks some of the beams. A controller chip calculates the finger position from “no light” signals from the detectors.

- **Surface acoustic wave**, automatic tellers, subway tickets, gambling and kiosks.
  - Similar to infrared, but uses ultrasonic waves produced by piezoelectric transducers. Transducers on the opposite side of the screen convert the ultrasound back into electrical signals. The finger absorbs some of the ultrasound energy, changing the signal, which the controller uses to map the point touched.

**Finding the right spot**

A voltage gradient is first applied across the top layer through metal or insulated bus bars on left and right sides. Pressure on the screen creates an electrical contact, producing a specific voltage on the glass layer depending on where along the horizontal axis the touch occurs. Location along the vertical axis is determined the same way by applying a voltage gradient across the glass layer through bus bars on the top and bottom. A converter changes the analog electrical signals to digital code, and a controller chip determines the horizontal and vertical coordinates.